NASA and Air Force Cost Model 99 (NAFCOM99) Overview and Related Activities

March 2000 NASA Cost Estimating Symposium

3/1/2000

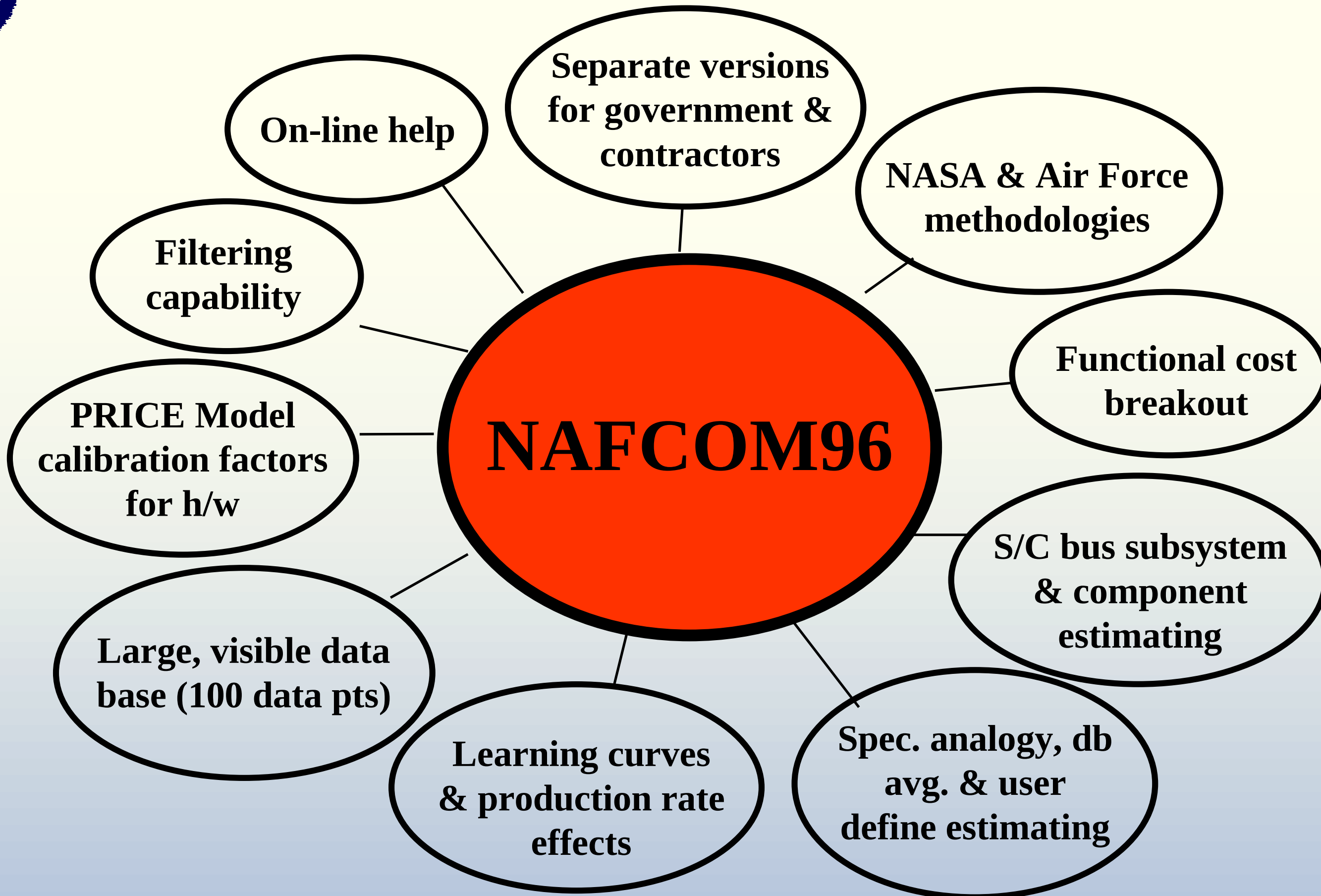
Agenda

- NAFCOM Cost Model
  - Introduction
  - NAFCOM96 Overview
  - NAFCOM99 Overview
  - PRICE Complexity Factors
  - Instrument Module
  - Liquid Rocket Engine Module
  - Complexity Generators
  - Demonstration
  - NAFCOM99 Training
- NAFCOM Website
- Resource Data Storage and Retrieval (REDSTAR) Web Site

NAFCOM Introduction

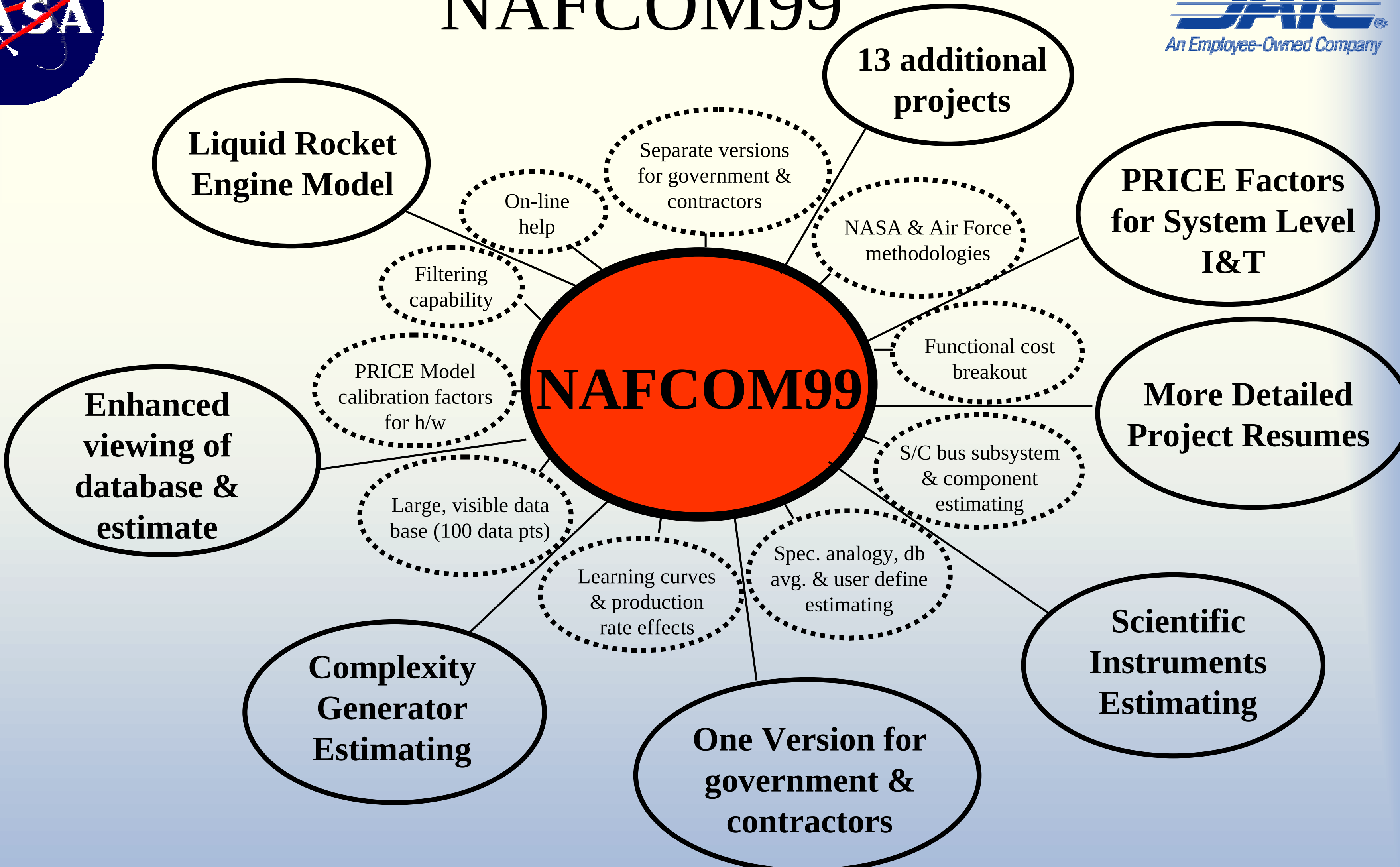
- Estimates space hardware development and production costs based on historical data
- Uses cost estimating relationships (CERs) which correlate historical costs to mission characteristics to predict new project costs
- Is intended to be used in Formulation phase estimating
- Applicable to various types of missions (manned, unmanned Earth Orbiting, launch vehicles)
- Included data represents the best of the aerospace project data within REDSTAR
- Can be used for high level, “ball park” estimates or low-level, detailed estimates

NAFCOM96



- 130 users of “government only version”, 250 users of “contractor version”
- Approximately 100 received formal training

NAFCOM99



- Selected as one of two projects to represent MSFC in the “NASA Software Advisory Council’s 1999 Software of the Year Contest”
- Approximately 165 government users

PRICE Complexity Factors

- NAFCOM provides calibrated PRICE-Hardware Model (PRICE-H) factors which can be used as inputs for PRICE-H estimates.
- The PRICE-H Model is a widely used, commercially available tool designed for parametric estimating of commercial & government development efforts.
- Some PRICE-H inputs require detailed technical data that is often not available to NASA estimators in early program stages and tables offered to assist in deriving the inputs are not well-suited for NASA hardware.
- SAIC conducted an exercise to calibrate PRICE-H to an early design, aerospace environment, producing approximately 600 calibrated manufacturing complexity factors, thus keeping NASA PRICE users from having to interpret the PRICE tables.
- Factors were calibrated for group/subsystem level items as well as for system integration.
- Average complexity factors or complexity factors for analogous data points can be obtained from NAFCOM and used in PRICE-H.

PRICE Complexity Factors (cont.)

- Calibrated factors for group/subsystem items include:
  - ***Manufacturing Complexity of Structure (MCPLXS)*** - a measure of the item's technology, its producibility, and all labor and material required to produce the item.
  - ***Engineering Complexity (ECMPLX)*** - a measure of the complicating factors of the design effort as they relate to the experience of the design team
  - ***Percent of New Structure (NEWST)*** - the amount of new design
- Calibrated factors for system integration or Integration & Test (I&T) include:
  - ***Engineering Complexity (ECMPLX)*** - a measure of the complicating factors of the design effort as they relate to the experience of the integration team.
  - ***Structural Plans and Procedures (SPLANS)*** - the level of structural engineering tasks performed in developing integration and test plans and procedures for the system.
  - ***Mechanical Integration Factor (INTEGS)*** - the level of mechanical/structural contribution of an element to the system Integration and Test effort

PRICE Subsystem Calibration Exercise

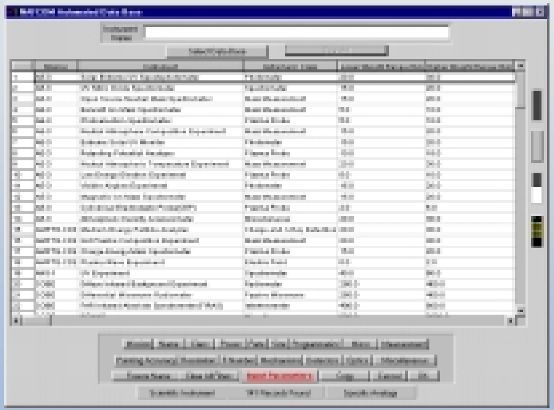
- Complexities were calibrated with structure and electronics combined thus removing the guesswork in trying to separate the two types of hardware
- First step was to calibrate to the historical Prototype (or flight unit) cost and generate a complexity value using PRICE's ECIRP mode and setting inputs for number of prototypes, weight, platform value, NEWST, ECMPLX.
- Second step was to run the model forward to model development cost.
  - NAFCOM99 D&D cost was target
  - ECMPLX and NEWST were varied until target cost was achieved
- Separate sets of factors were calibrated using NASA-normalized cost data and Air-Force normalized cost data.

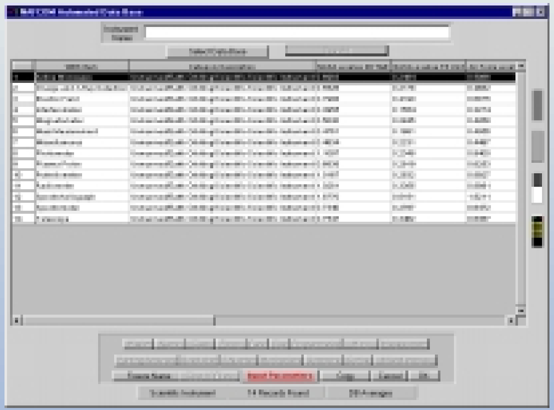
PRICE I&T Calibration Exercise

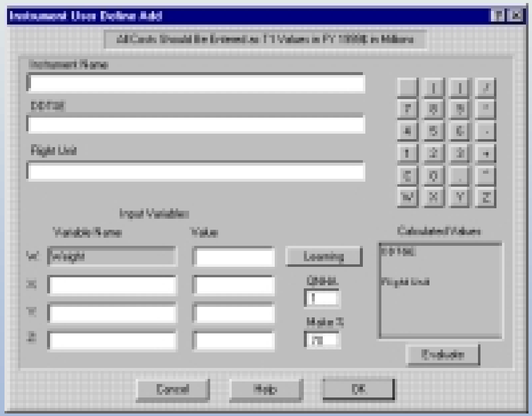
- For each NAFCOM historical mission, an I&T element was added to calculate the I&T cost for the calibrated subsystems.
- Inputs for I&T ECMPLX and SPLANS, and for subsystem INTEGS were varied until the total I&T cost estimated by PRICE matched the target NAFCOM system integration cost.
- Separate sets of factors were calibrated using NASA-normalized cost data and Air-Force normalized cost data.

Instrument Module

- Database contains over 360 data points from over 100 missions
- NAFCOM conventional estimating methodology applied, using NAFCOM "first pound cost" CERs
- Average first pound costs are derived from data point selections and used in the NAFCOM cost equation, along with inputs for weight and complexity, to estimate new instrument hardware

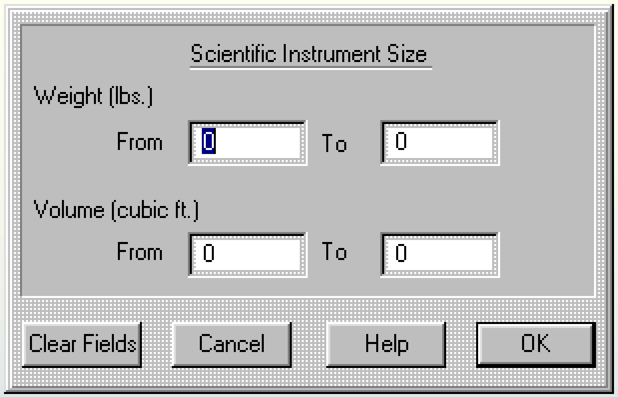


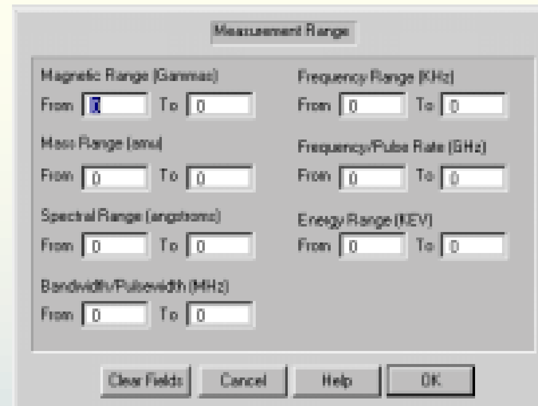


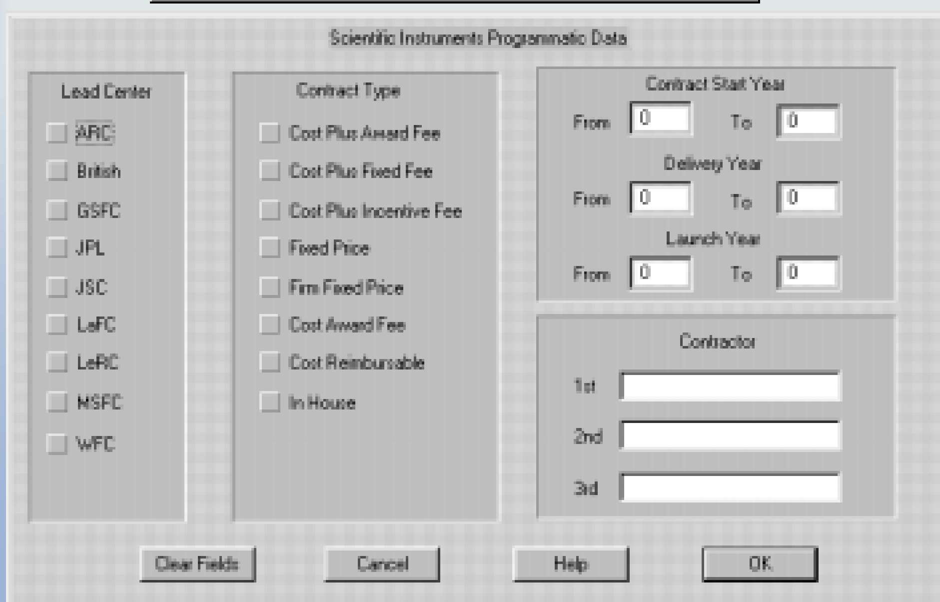


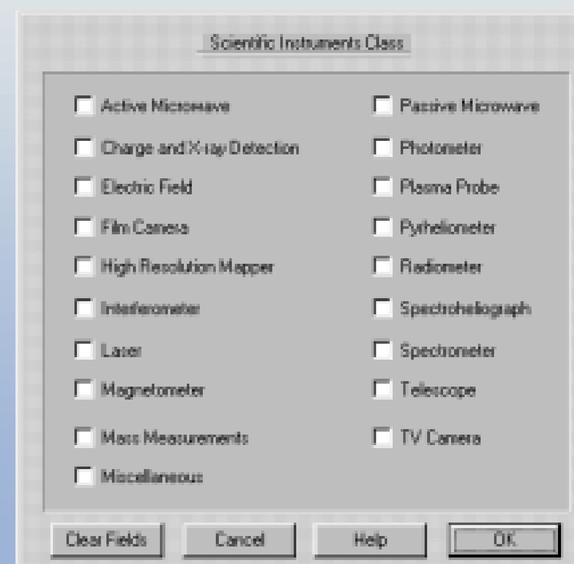
Instrument Module

- Data sort and search capability offering over 25 filters to assist in segregating the data by technical and programmatic characteristics







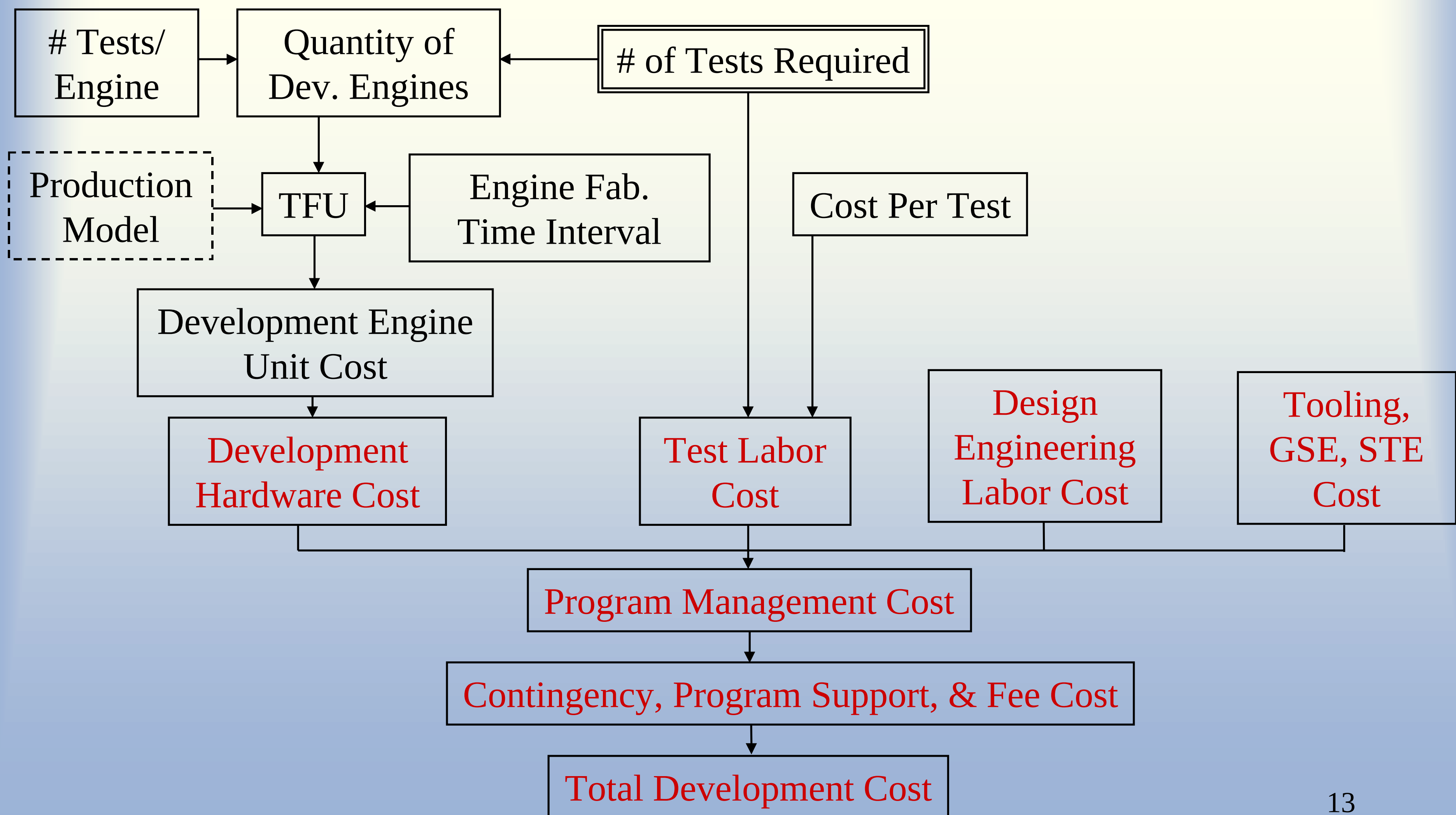


Liquid Rocket Engine Module

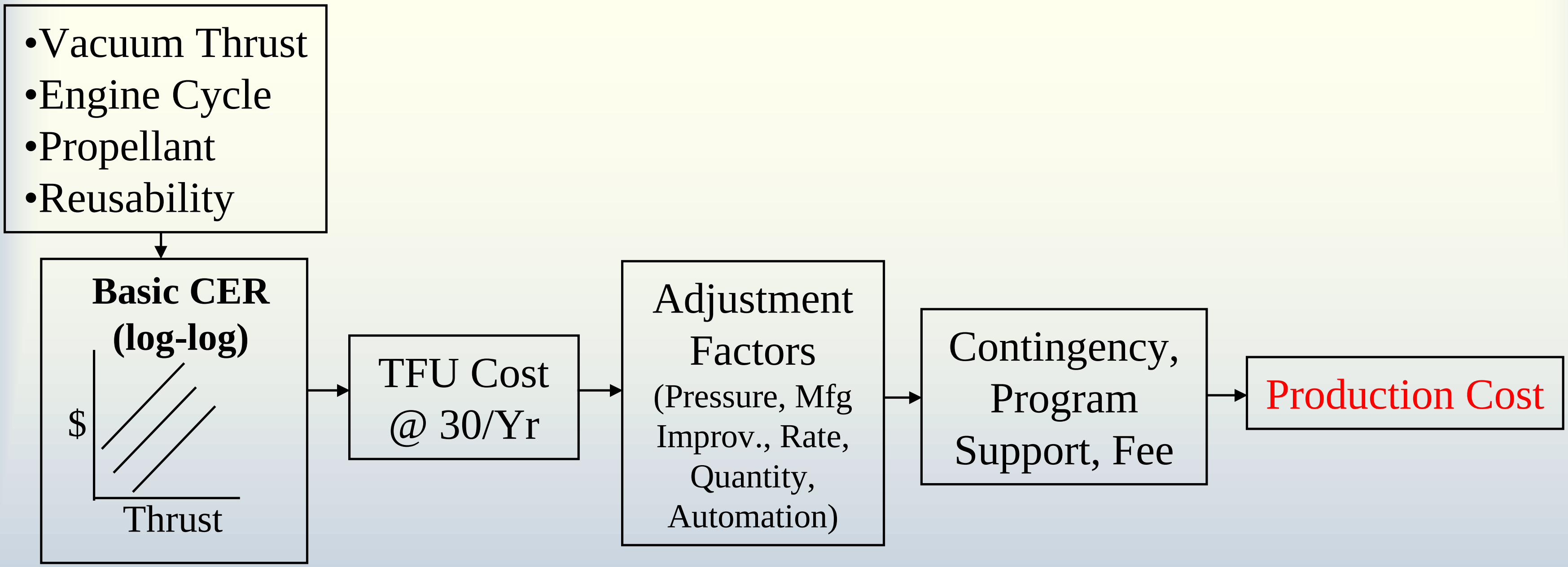
- Based on Rocketdyne's Liquid Rocket Engine Cost Model (1997)
- Estimates at component level or engine level
- CERs were derived with the technical and cost data of Rocketdyne's engines, including six actually produced engines (F-1, J-2, J-2S, RS-27, MA-5, SSME) and other relevant data sources (STME, Peacekeeper Stage IV, Lance, ASE, Derivatives of Historical Rocketdyne Engines).
- CERs are a function of technical, size, complexity and process improvement parameters

Overview of Development Model

- Core of the development model is the calculated Number of Tests Required for Certification



Overview of Summary Production Model



Overview of Detailed Production Model

- Total Engine Hardware Cost
  - Engine Assembly
  - Engine System
    - Small Valves/Actuators
    - Lines and Small Ducts
    - Instrumentation
    - Controller
    - Hot Gas Ducts
    - Heat Exchanger
    - Other
  - Six Major Component Groups
    - Turbopumps
      - LOX Pumps
      - Fuel Pumps
      - Gearbox
      - High Pressure Pumps
      - Low Pressure Pumps
      - Jet Pump Inducer
    - Ducts
      - Inlet Ducts
      - Discharge Ducts
      - Flex Joints
    - Thrust Chambers
      - Main Chamber
      - Regen Cooled
        - Dump Cooled
        - Tubular Nozzles
    - Main Valves
      - LOX Valve/Actuator
      - Fuel Valve/Actuator
    - Gimbal
      - Gimbal Bearing
      - Gimbal Structure
      - Gimbal Actuator
    - Injectors (Main, GG, Preburners)
      - Main Injector
      - Main Injector Dome
      - GG/Preburner Injector
      - GG/Preburner Injector Dome

Exclusions:

- Non-Tubular Nozzle Extensions
- Retraction Mechanism
- Thrust Frames

Overview of Detailed Production Model (cont.)

Component Group	Size Parameter	Complexity Discriminators (CER Choices)
Ducts	Component Weight	Fuel Type: H2 or RP-1 Complexity: High or Low
Gimbal	Component Weight	None
Injectors	Component Weight	Coaxial vs. Doublet Construction
Main Valves	Component Weight	Fuel Type: H2 or RP-1
Thrust Chambers	Component Weight	Milled Channel vs. Tube Construction
Turbopumps	Turbopump Torque Component Weight	Number of Key Parts

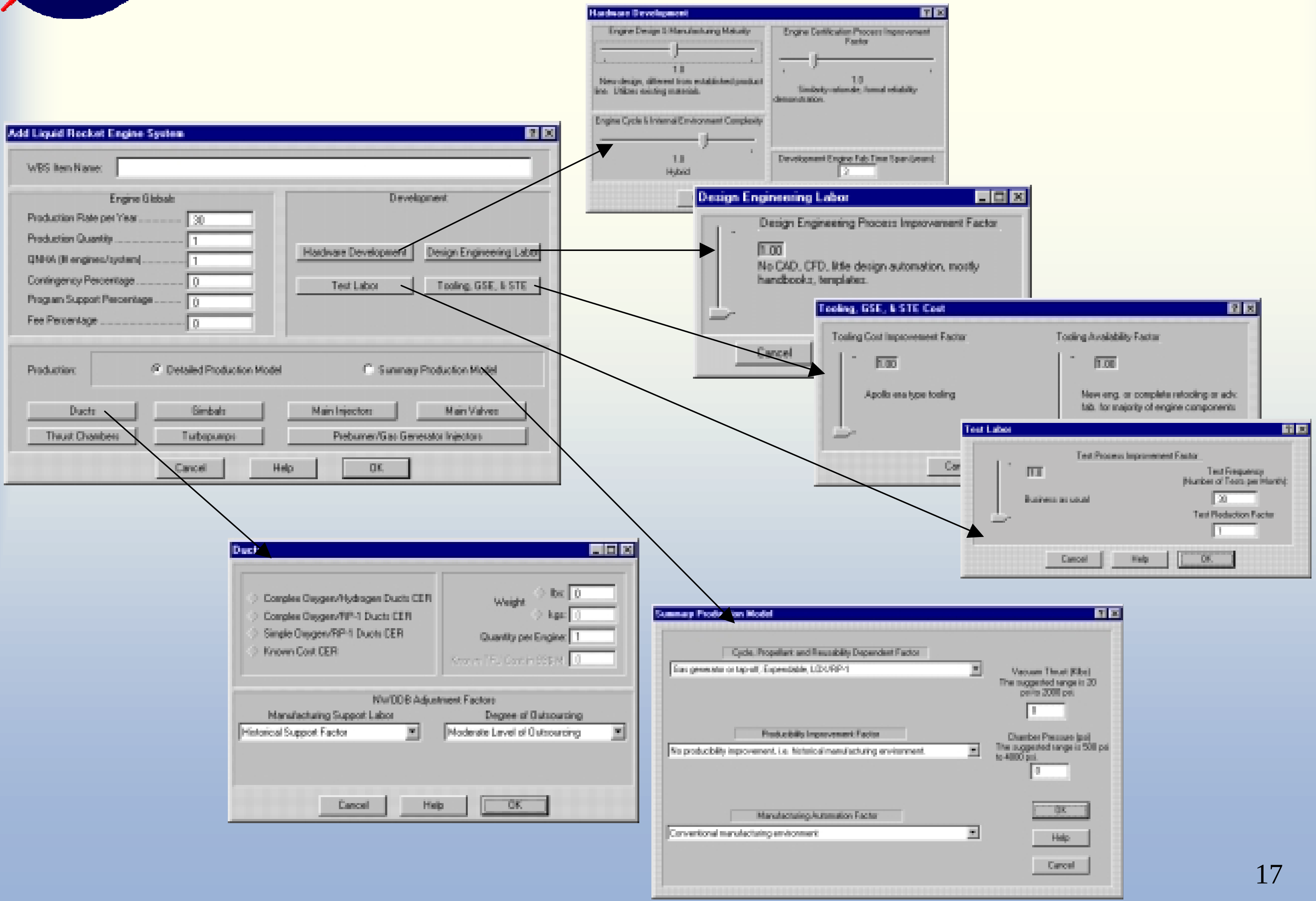
TFU per Component Cost = ((CER Coefficient * Weight ^ Size Exponent * Level of Mfg Support Factor * Degree of Outsourcing Factor) * Production Rate Adjustment Factor)

Engine System Cost = 0.3386 * Total of Component Costs

Final Assembly Cost = 0.0346 * (Total of Component Costs + Engine System Costs)

Contingency, Program Support and Fee costs are calculated by user-defined % of the total of the engine components and assembly costs

Liquid Rocket Engine Module



Complexity Generators

- Cost complexity is caused by a combination of cost drivers including:

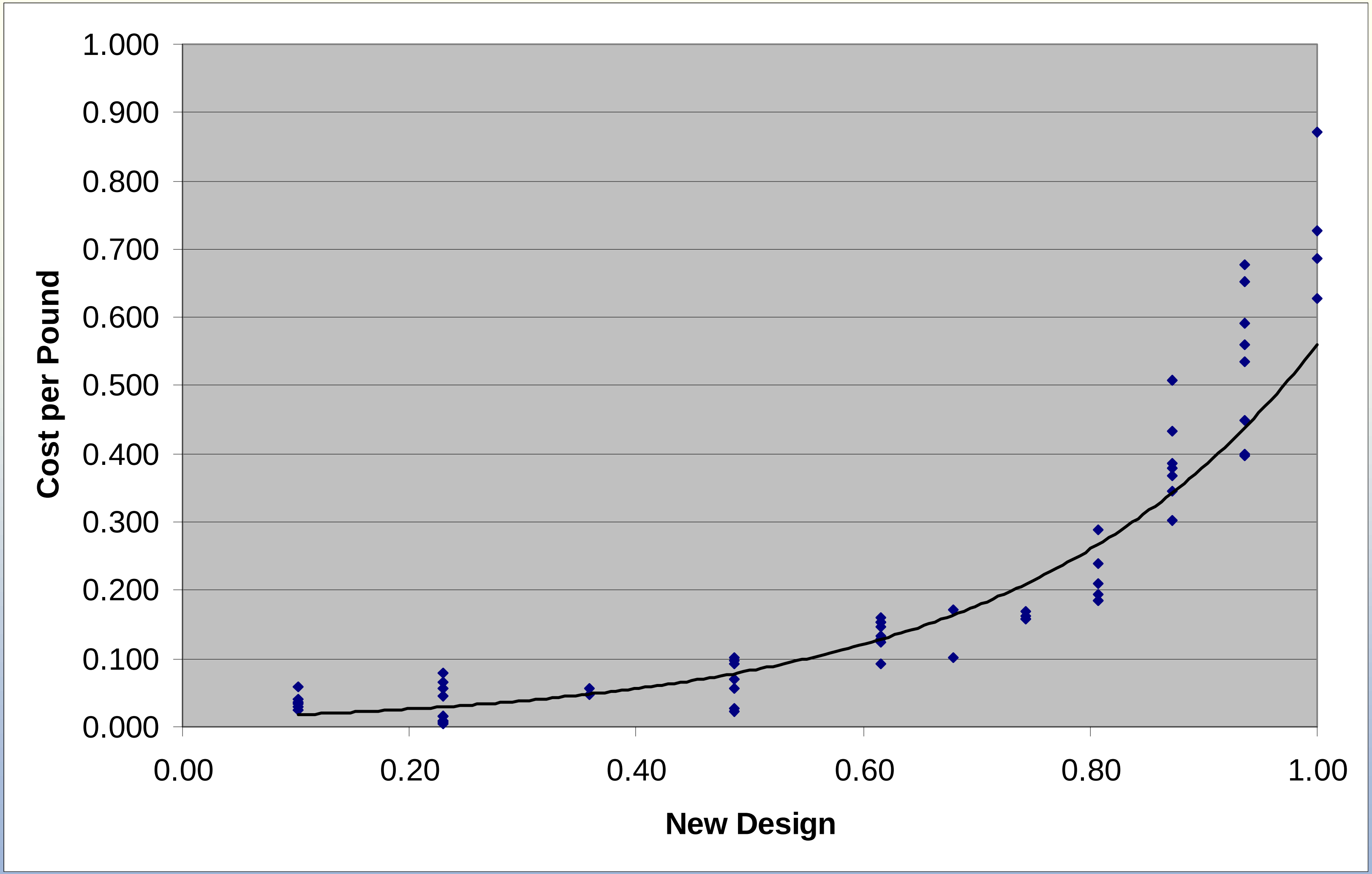
Risk Management	Weight	Staff Experience	TRL
Design Methods	Tech. Advancement	Performance	Inheritance
Design Complexity	Requirements Change	Design Life	Redundancy
Test Requirements	Management Methods	Interfaces	Operating Modes

- With establishment of the large NAFCOM database to work from, it became possible to develop a unique analytical process, called Complexity Generators, to segregate and quantify each of the cost drivers.
- Each subsystem has its own specific set of Complexity Generators geared to its unique cost drivers.
- By specifying new projects' cost drivers through Complexity Generator inputs, cost estimates become much more accurate and previously unaccounted for costs (+ & -) are included.

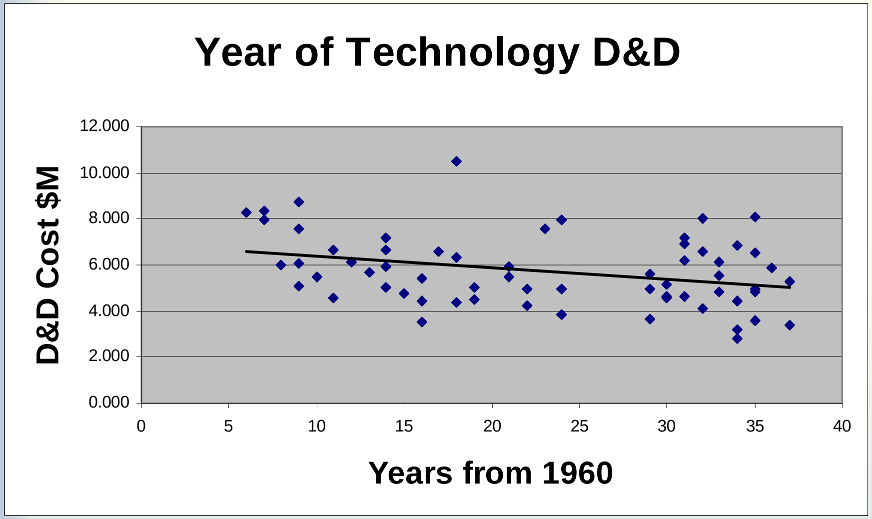
Data Analysis

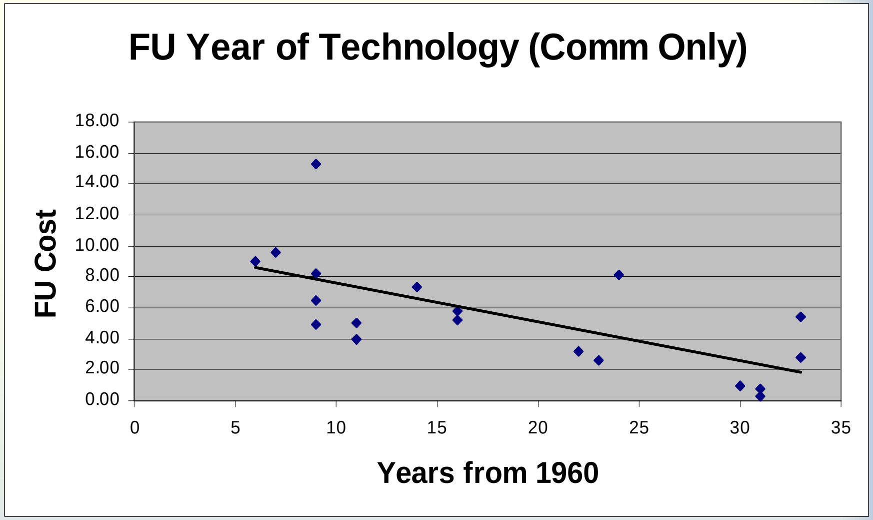
MISSION	Weight	D&D Cost	FU Cost	Data Base	DB Rating	Design Life	Launch Year	Year Factor	Storage Capacity	Output Power
TDRSS	1084	40.44	7.69	EO	1	120	1983	17	120	1700
TIROS-M	96	5.05	0.58	EO	1	60	1970	40	8	400
TIROS-N	303	0.59	0.98	EO	1	60	1978	22	60	1250
TOMSEP	117	3.27	1.73	EO	1	36	1996	11	9	275
TOPEX	1480	18.07	8.44	EO	1	60	1992	13	150	2101
UARS	1850	32.24	8.97	EO	1	36	1991	13	150	2400
UFO	731	1.58	2.07	EO	1	36	1993	12	100	2500
VELA-IV	101	6.48	2.66	EO	1	18	1967	57	12	180
SRB	944	135.23	5.60	LV	6	60	1981		400	1000
Centaur-D	168	42.94	1.20	LV	6	12	1966		200	1000
S-IC	3723	216.54	22.63	LV	6	12	1968		800	1000
S-IVB	1495	88.12	1.13	LV	6	12	1968		650	1000
S-II	1157	66.51	10.61	LV	6	12	1968		560	1000
External Tank	587	34.82	2.45	LV	6	12	1981		300	1000
IUS	581	21.50	2.77	LV	6	12	1982		300	1000
Gemini	827	301.57	6.74	Manned	12	24	1965		225	2000
Apollo CSM	3100	655.06	26.66	Manned	12	30	1968		3000	1500
Apollo LM	1394	386.23	12.23	Manned	12	30	1968		2200	1500
Shuttle Orbiter	14118	541.64	190.42	Manned	12	240	1981		6000	24000
Spacelab	2079	90.49	24.81	Manned	12	120	1983		3000	7000
Skylab Airlock	3850	91.85	25.01	Manned	12	60	1973		2000	1500
Skylab OWS	8051	136.49	26.53	Manned	12	60	1973		3500	12000
Galileo Orbiter	542	132.93	36.76	Planet	5	72	1989		60	570
Voyager	406	110.08	14.57	Planet	5	72	1977		33	450
Surveyor	90	30.19	6.52	Planet	5	12	1966		12	3650
Pioneer-10	200	41.68	20.23	Planet	5	36	1972		30	700
Viking Lander	388	48.52	13.65	Planet	5	2	1975		32	70
Lunar Orbiter	92	16.88	2.17	Planet	5	12	1966		12	448

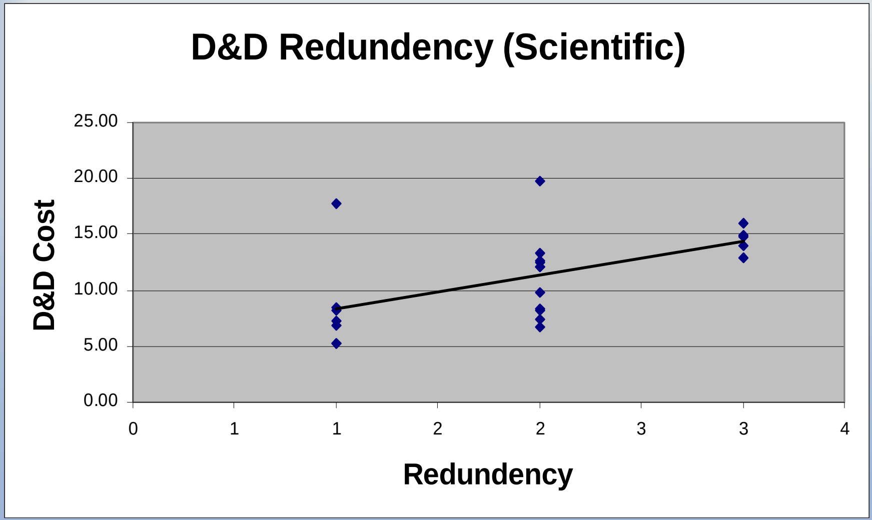
Cost Driver - New Design

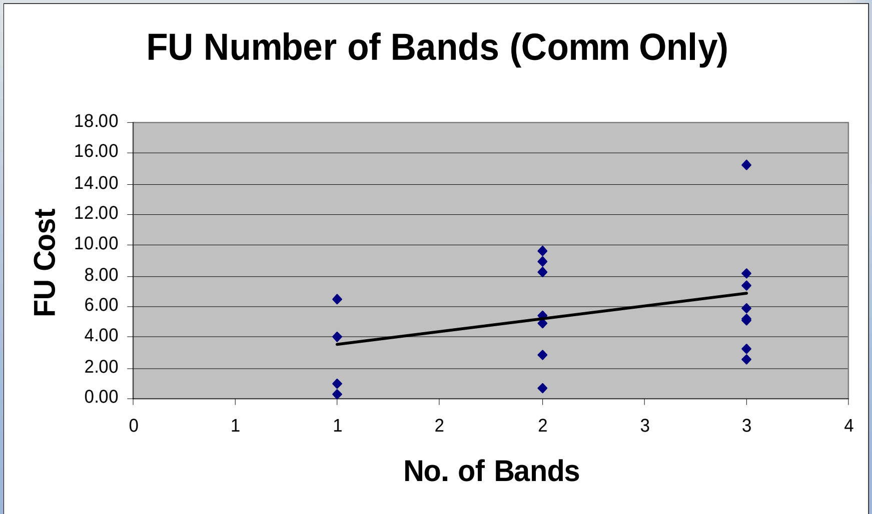


Cost Drivers - Technology









Cost Drivers - Mgmt. Approaches

- Define a weighting for each management driver based on the trend analysis of NAFCOM cost driver data base, engineering judgement, and SSCAG NWODB survey results
- Assign management cost driver values for each mission in NAFCOM

MISSION	DDT&E Cost	Unit Cost	Manu. Mgmt	Funding Avail.	Test Approach	Integ. Complex.	Engineering Mgmt	Pre-C/D
ACTS	6.711	1.906	53	25	50	50	68	60
AE-3	6.900	2.443	45	25	75	25	55	80
AEM-HCMM	0.980	0.846	60	50	50	50	45	60
ALEXIS	0.123	0.073	45	25	50	50	60	60
AMPTE-CCE	1.542	0.401	45	25	75	25	65	60
ATS-1	0.430	0.148	45	25	75	50	38	60
ATS-5	6.431	1.674	75	50	25	50	68	60

Complexity Equations

- Equations have been developed for Design and Production for each subsystem that estimate cost based on Weight, New Design, Technology, and Management factors.
- The equations follow the form:

$$\text{Cost} = C * \text{Weight}^{\wedge W} * \text{New Design}^{\wedge X} * \text{Technology}^{\wedge Y} * \text{Management}^{\wedge Z}$$

- The values of C, W, X, Y, and Z were derived from least squares minimization of:

$$\Sigma \{(\log(\text{Cost}) - \log(C) - W * \log(\text{Weight}) - X * \log(\text{New Design}) - Y * \log(\text{Technology}) - Z * \log(\text{Management})) \wedge 2\}$$

Cost Drivers

General (applies to all)
New Design
Weight
Launch Year
Engineering Management
Manufacturing Management
Risk Management
Funding Availability
Integration Complexity
Pre-development Studies

Attitude Control
Stabilization Method
Types of Sensors
Computer or Radar
Autonomy
Redundancy

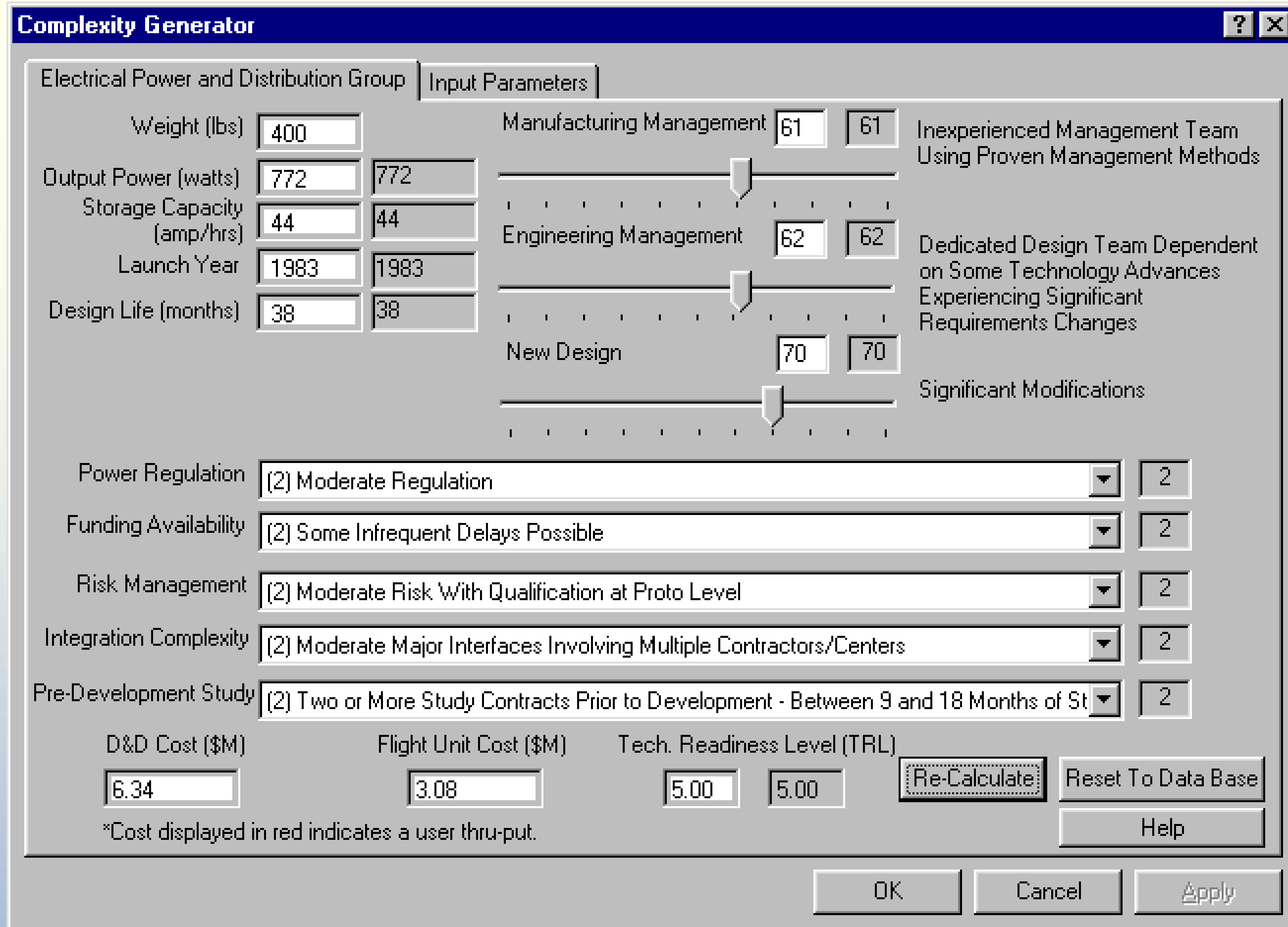
Structures
Structural Efficiency
Deployables

Control & Data Handling
Spacecraft Class
Frequency Bands
Number of Transmitters
Redundancy

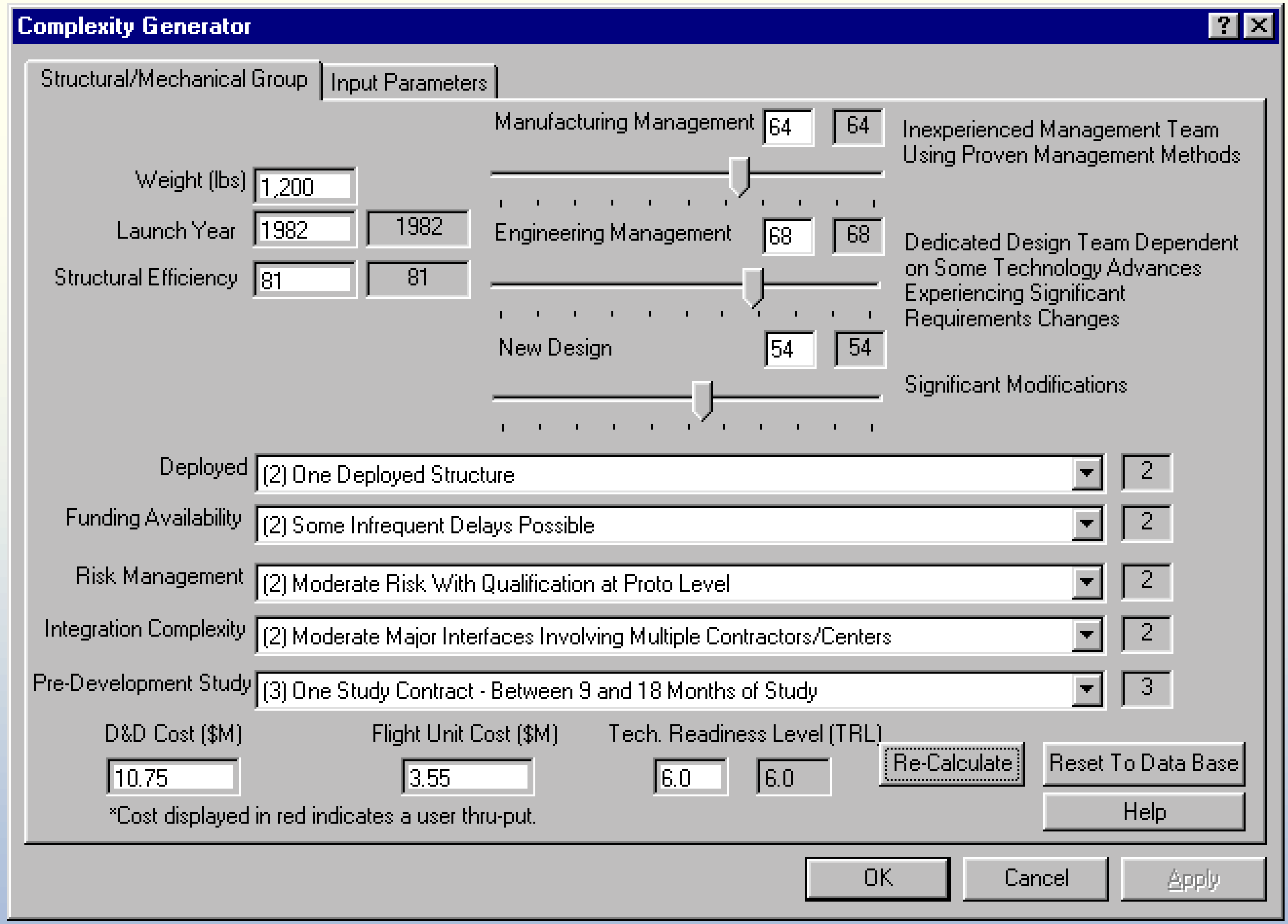
Electrical Power
Output Power
Storage Capacity
Design Life
Power Regulation

Reaction Control
Specific Impulse
BOL Thrust
Propellant Weight
Propellant Type

Electrical Power

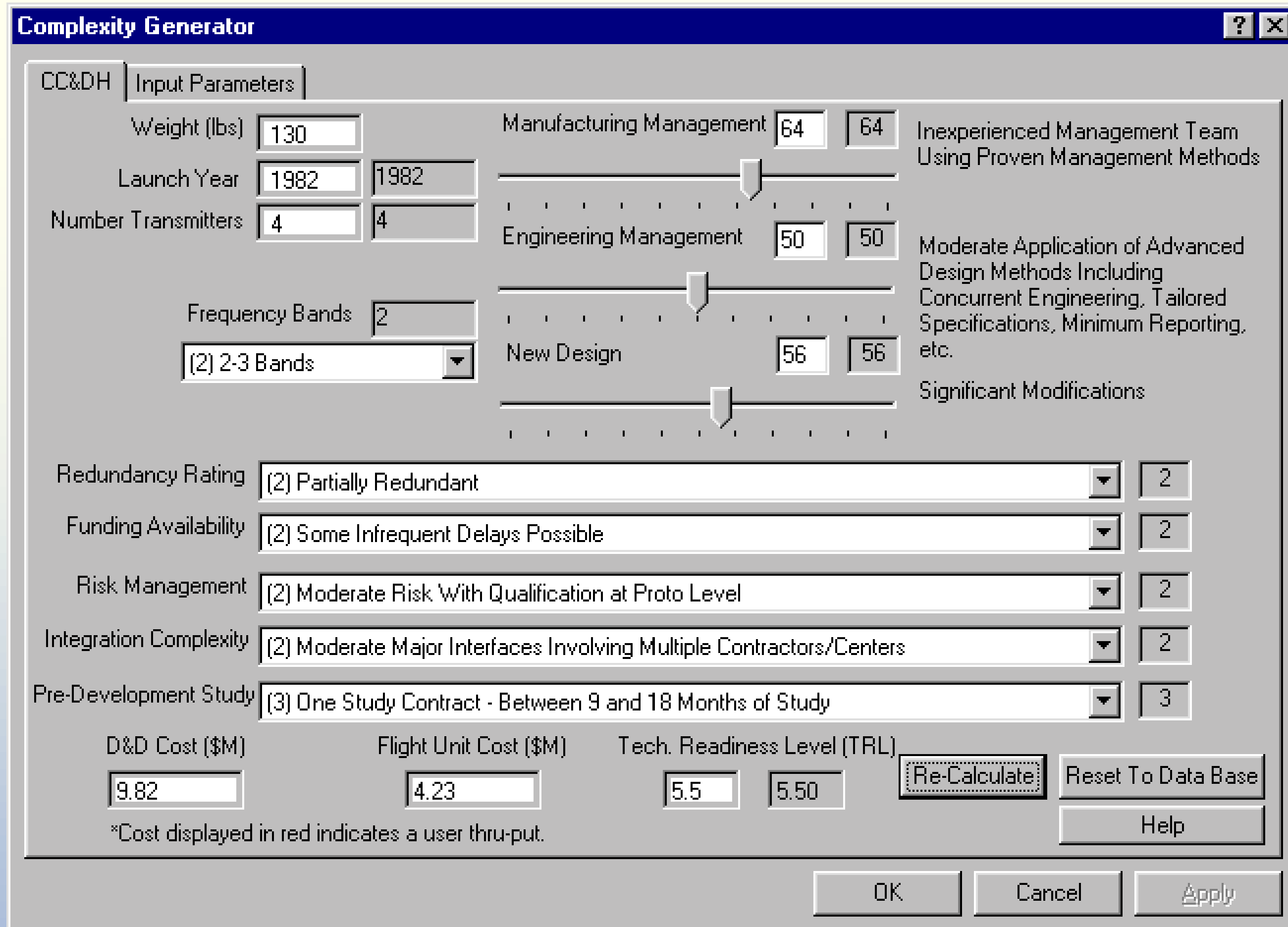


Structures

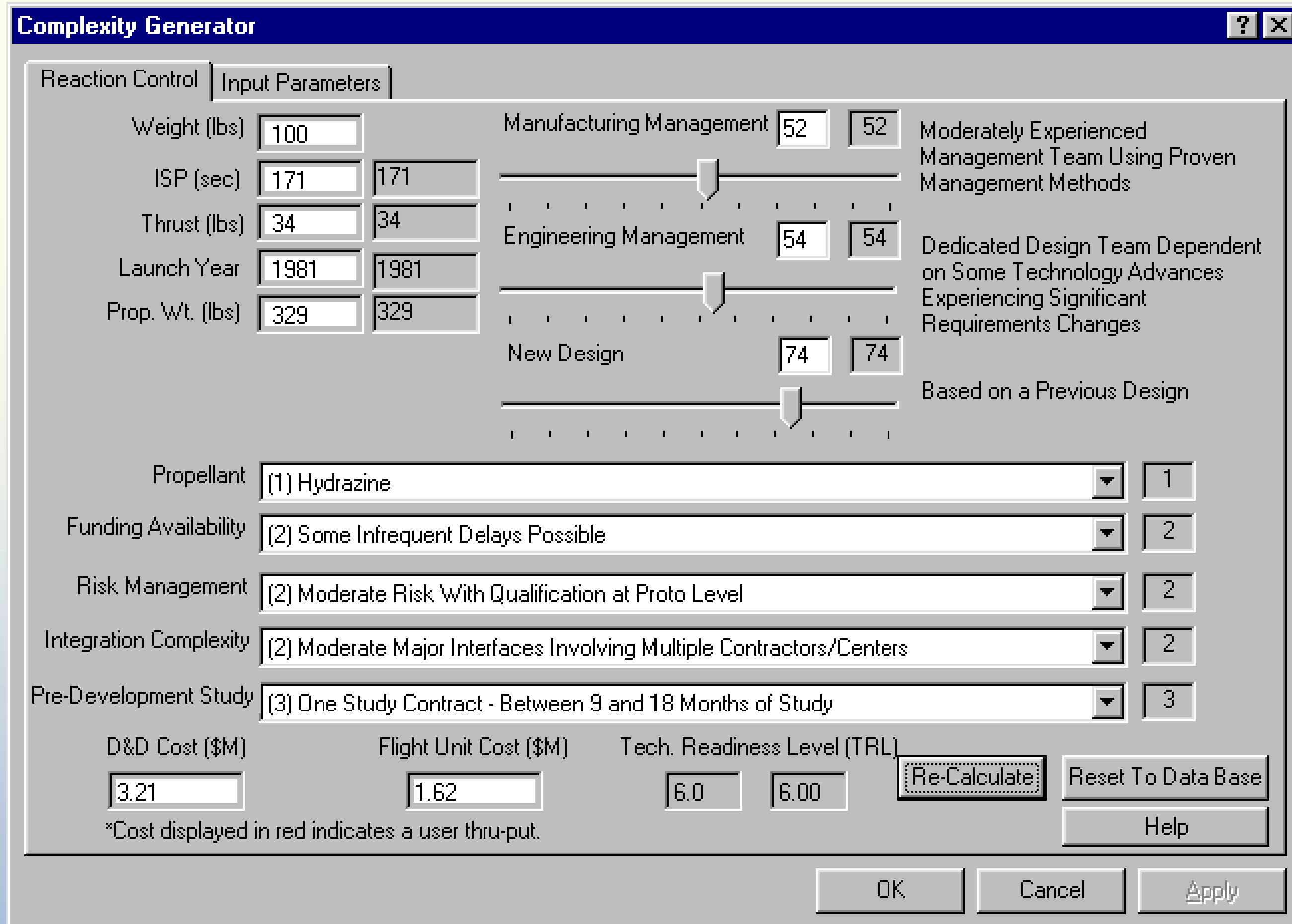


Complexity Generator
Structural/Mechanical Group
Input Parameters
Manufacturing Management 64 64
Inexperienced Management Team Using Proven Management Methods
Weight (lbs) 1,200
Launch Year 1982 1982
Structural Efficiency 81 81
Engineering Management 68 68
Dedicated Design Team Dependent on Some Technology Advances Experiencing Significant Requirements Changes
New Design 54 54
Significant Modifications
Deployed (2) One Deployed Structure 2
Funding Availability (2) Some Infrequent Delays Possible 2
Risk Management (2) Moderate Risk With Qualification at Proto Level 2
Integration Complexity (2) Moderate Major Interfaces Involving Multiple Contractors/Centers 2
Pre-Development Study (3) One Study Contract - Between 9 and 18 Months of Study 3
D&D Cost ($M) 10.75
Flight Unit Cost ($M) 3.55
Tech. Readiness Level (TRL) 6.0 6.0
Re-Calculate
Reset To Data Base
Help
*Cost displayed in red indicates a user thru-put.
OK
Cancel
Apply

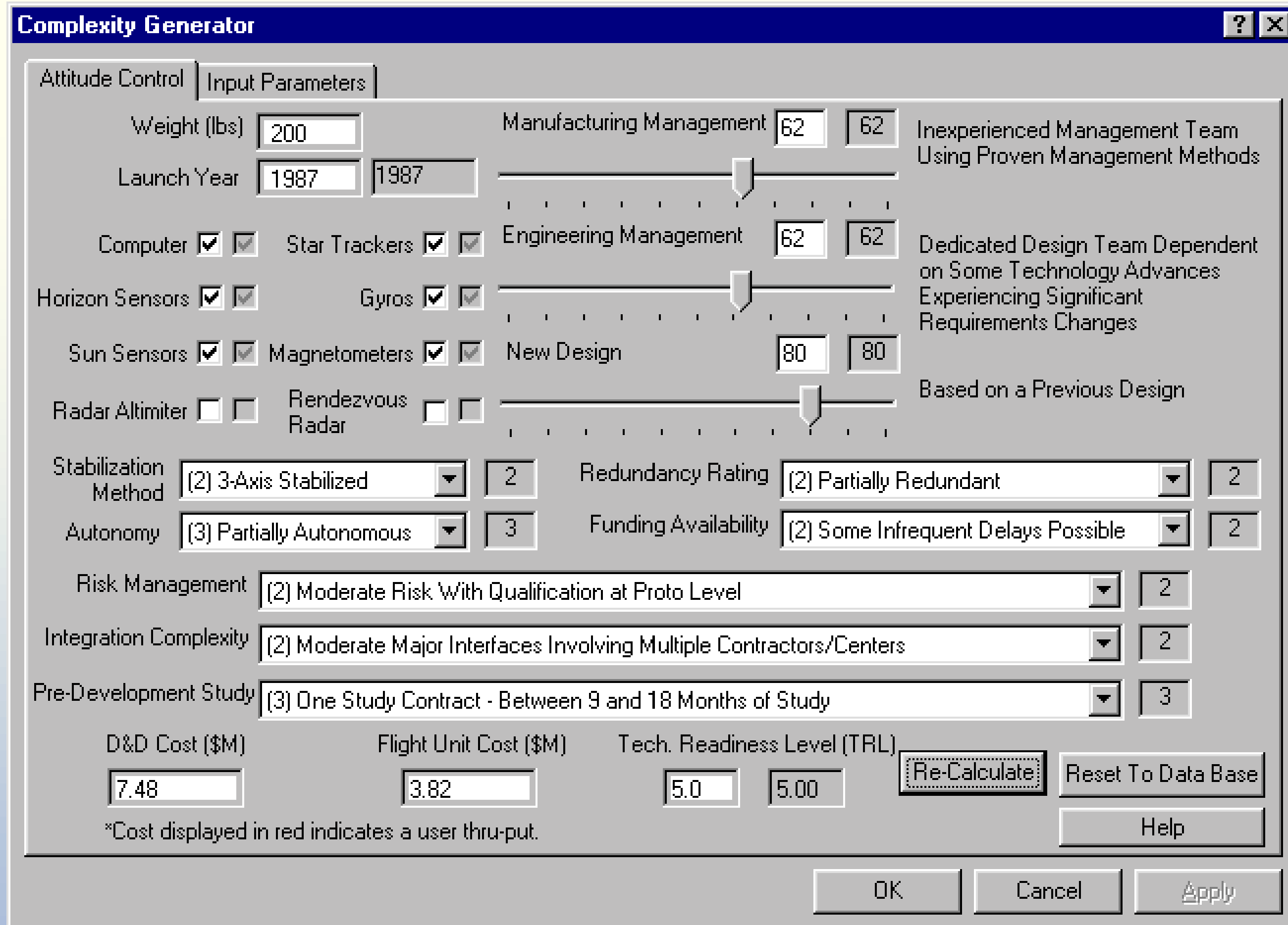
Command, Control & Data Handling



Reaction Control



Attitude Control



Complexity Generators - Summary

- Provides a more defendable method for capturing the complexity of the element and adjusting cost, than does applying the user defined complexity factors for the Conventional CERs
- Uses multivariable equations with several common and subsystem-unique cost driving technical & programmatic variables to estimate cost
- User can choose data points from the specific analogy or database average databases to establish initial or “default” inputs required for the Complexity Generator CERs

NAFCOM99 Demonstration

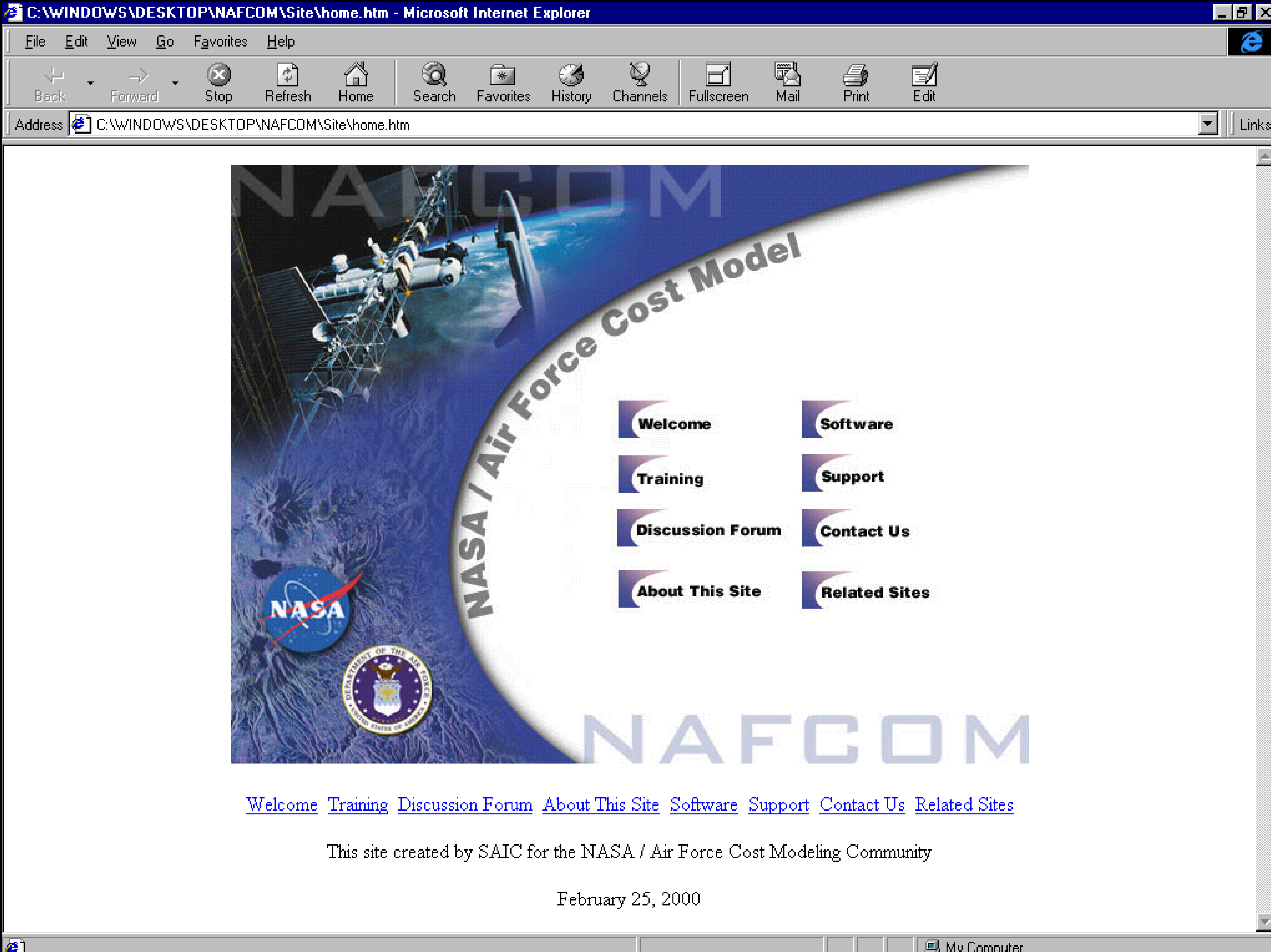
NAFCOM99 Training

Organization/Location	Dates	# of Attendees
MSFC	2/1-2/2	6
	2/3-2/4	4
	2/8-2/9	2
AFCAA	2/15-2/16	8
AF/SMC	2/23-2/24	9
	4/11-4/12	?
JSC	3/28-3/29	?
ARC	TBD	?
LaRC	TBD	?

NAFCOM Website

nafcom.saic.com

- Currently under construction
- Offers such features as:
  - Software upgrade downloading (password protected)
  - Viewing & downloading of training manuals, documentation, input sheets, newsletters, sample files
  - Model demonstrations
  - Frequently Asked Questions
  - Discussion Forum
  - Training Schedules
  - Forms for asking questions, reporting problems, requesting software, subscribing to the newsletter mailing list or signing up for training
  - Site searching capability
  - Links to related sites


C:\WINDOWS\DESKTOP\NAFCOM\Site\home.htm - Microsoft Internet Explorer
File Edit View Go Favorites Help
Back Forward Stop Refresh Home Search Favorites History Channels Fullscreen Mail Print Edit
Address C:\WINDOWS\DESKTOP\NAFCOM\Site\home.htm
Links
NAFCOM
NASA / Air Force Cost Model
Welcome
Software
Training
Support
Discussion Forum
Contact Us
About This Site
Related Sites
NASA
NAFCOM
Welcome Training Discussion Forum About This Site Software Support Contact Us Related Sites
This site created by SAIC for the NASA / Air Force Cost Modeling Community
February 25, 2000
My Computer

REDSTAR Library

- Resource Data Storage and Retrieval (REDSTAR)
- NASA's major repository of cost, technical, and programmatic information since 1971
- REDSTAR contains over 22,000 documents, representing over 500 corporate authors including government agencies, companies, aerospace societies, and universities.
- Supervised by a masters-degreed librarian
- Contains source data for all Engineering Cost Office modeling efforts including NAFCOM
- Over 1,000 square feet of space with 122 file cabinets

REDSTAR Library

REDSTAR CD-ROM Library

REDSTAR Web Page

redstar.saic.com

- Currently scanned 7,500 of the 22,000+ documents in REDSTAR
- The REDSTAR electronic library contains approximately 1,000,000 pages of information
- All 7,500 documents are now available on the web
- Document access is password protected
- Search routines allow simple to comprehensive searching
- Documents can be downloaded for local viewing, printing, or distribution

REDSTAR Development

- The REDSTAR web-site is the result of systems integration expertise developed by SAIC to rapidly integrate the many required components into a cohesive system.
- The components operating behind the scenes include:
  - A database system and search engine to allow the user to find the documents they need
  - An imaging system to store and backup the documents, and to serve up the documents for online viewing, downloading and printing
  - Security to protect the sensitive data and the site itself from misuse
  - Communication with the library and development staff directly from the web-site for support
  - An internet server to host all of these components and deliver the library to users with any browser running on any operating system
  - A web-site based user interface to coordinate all of these components into a single, user-friendly interface

REDSTAR Home Page - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address http://redstar.saic.com/

REDSTAR

RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

NASA

REDSTAR is the Resource Data Storage and Retrieval system of the National Aeronautics and Space Administration (NASA). It was established by the Marshall Space Flight Center's Engineering Cost Office in 1971 as a NASA-wide repository of cost, programmatic and technical data pertaining to space related projects and programs.

Maintained by Science Applications International Corporation, REDSTAR currently totals approximately 21,000 documents. Detailed data, including viewing and/or downloading of documents, is available for use by NASA employees at all NASA Centers and Headquarters through the use of passwords. Others may search for key words and review document titles only.

Login

This site works best with Internet Explorer 4.01 or higher and Netscape 4.5 or higher. If you do not already have one of these browsers then please select one of the two choices below.

GET Microsoft Internet Explorer

Netscape Now!

Done Internet

http://redstar.saic.com/Login.asp - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address http://redstar.saic.com/Login.asp Go Links

Login

RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

SENSITIVE DATA

Distribution of the data contained in REDSTAR is limited to agencies of the United States Government; it is not for foreign distribution and not for public release.

Guest

Please login using your username and password. You can also choose to login as a guest.

Login Name:

Password:

Login

If you would like to request a password, please use the online password request form

Done Internet

http://redstar.saic.com/Verify.asp - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address http://redstar.saic.com/Verify.asp Go Links

REDSTAR
RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

- Welcome
- Browse
- Search
- Catalog #

Search Results
- Details
- Results

- Contact Us
- Help
- Links

Welcome

RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

Thank you, smithk , your password was confirmed.

Browse	Browse REDSTAR by document title.
Search	Perform simple or complex document searches.
Catalog	View document by entering catalog number.

Help | Feedback | Password Request | Change Password

Internet

http://redstar.saic.com/frame_B.asp - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address http://redstar.saic.com/frame_B.asp Go Links

REDSTAR
RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

- Welcome
- Browse
- Search
- Catalog #
- Search Results
  - Details
  - Results
- Contact Us
- Help
- Links

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Number of matching documents found: 111

Detail	1.5 STAGE COST PER FLIGHT BETA DISTRIBUTION
Detail	1.5KW FUEL CELL POWERPLANT CATALYST INVESTIGATION
Detail	10/8 BIT SOLID STATE SPACECRAFT DATA RECORDER
Detail	10/9 STR TAPE RECORDER FOR SHUTTLE REVIEW
Detail	100 KN SPACE STATION--THE
Detail	10TH ANNIVERSARY: DECADE ON BOARD SPACE SHUTTLE (MISSION CHRONOLOGY)
Detail	120" SRM/MDAC ORBITER--H.S. BOOSTER
Detail	12TH AEROSPACE MECHANISMS SYMPOSIUM: DEPLOYABLE ANTENNA REFLECTOR
Detail	12TH AEROSPACE MECHANISMS SYMPOSIUM: DEPLOYABLE TRUSS FOR SEASAT
Detail	156 INCH DIAMETER SRM MASS PROPERTIES REPORT

Done Internet

http://redstar.saic.com/frame_S.asp - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address http://redstar.saic.com/frame_S.asp Go Links

REDSTAR
RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

Welcome

Browse
Search
Catalog #

Search Results
Details
Results

Contact Us

Help

Links

Search

RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

This search page is designed to provide quick access to documents by searching the titles of the REDSTAR documents. Additional search features, including keywords, are available using the Advanced Search.

Search Document Titles for:

Search

Done Internet

http://redstar.saic.com/frame_SG.asp - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address http://redstar.saic.com/frame_SG.asp Go Links

REDSTAR
RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

- Welcome
- Browse
- Search
- Catalog #
- Search Results
  - Details
  - Results
- Contact Us
- Help
- Links

Advanced Search

RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

Major Keyword : COST DRIVERS

Minor Keyword 1:

AND
OR

Minor Keyword 2:

Word(s) in Title: AND OR

Company Name:

Publication Date: (mm/dd/yyyy)

Entry Date: (mm/dd/yyyy)

Document Source:

Cost Technical Programmatic

REDSTAR Documents With Images On-line

Full REDSTAR Library

GO!

Done Internet

http://redstar.saic.com/frame_SG.asp - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit

Address http://redstar.saic.com/frame_SG.asp

REDSTAR
RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

- Welcome
- Browse
- Search
- Catalog #

Search Results
- Details
- Results

- Contact Us
- Help
- Links

Results

RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

Number of matching documents found: 22

View	Detail	DEVELOPMENT OF COST REDUCTION FACTORS FOR 1989 SPACE-BASED ARCHITECTURE
View	Detail	POTENTIAL COST DRIVERS FOR UNMANNED SPACECRAFT PROPULSION SUBSYSTEMS
View	Detail	POTENTIAL COST DRIVERS FOR UNMANNED SPACECRAFT ELECTRICAL POWER
View	Detail	MARS GEOSCIENCE SURVEYOR DRAFT RFP: MOS COST & RISK DRIVERS
View	Detail	PROGRAM COST GROWTH OF VARIOUS MISSIONS
View	Detail	DEFINITION INVESTMENT VS COST GROWTH (BY WERNER GRUHL)
View	Detail	COST SAVING POSSIBILITIES & REALITIES
View	Detail	INDEPENDENT ANNUAL REVIEWS: COST & SCHEDULE TRENDS (JO GUNDERSON PITCH)
View	Detail	COST OF CHALLENGER IMPACT, DELAYS, COMPLEXITY FOR TOPEX, OTHER MISSIONS

Done Internet

Detail

RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

View

Catalog #	10101940
Major Keyword	COST DRIVERS
Title	POTENTIAL COST DRIVERS FOR UNMANNED SPACECRAFT ELECTRICAL POWER
Company Name	ARI: APPLIED RESEARCH INCORPORATED
Publication Date	7/2/93
Entry Date	8/8/94
Resume Type	Cost and Technical Data
Minor Keywords	COST DRIVERS, INHERITANCE, POWER, AE-C, AEM-HCMM, AMPTE, ATS (GENERAL), ATS-1, ATS-2, ATS-5, ATS-6 (ATS-F), COBE, CRRES, DE-1 (DE-A), DE-2, DMSP-5D, DSCS-II, ERBS, GALILEO, GALILEO PROBES, GRO, HEAO-1 (HEAO-A), HST-SSM, IDCSP/A (SKYNET), INTELSAT, LANDSAT-1 (ERTS-1), LANDSAT-4 (LANDSAT-D), LUNAR ORBITER, M-35, MAGELLAN, MAGSAT, MARINER (GENERAL), MARINER-10, MARINER-4, MARINER-6, MARINER-8, OSO-8 (OSO-I), PIONEER VENUS, PIONEER VENUS PROBES, PIONEER-10, SCATHA (P78-2), SMS, SURVEYOR, TACSAT, TIROS-N, TIROS-M, VELA-IV, VIKING, VOYAGER (GENERAL),
Document Source	Jet Propulsion Laboratory
# pages	37

Applied Research, Inc.

Huntsville, Alabama • Arlington, Virginia

"Focused On The Future . . . Committed To Excellence"

Potential Cost Drivers for Unmanned Spacecraft Electrical Power Subsystems

July 2, 1993
ARI-93-R-062(Z)
Contract JPL 959313, CWO-5

-0/94

Prepared for

Download

RESOURCE DATA STORAGE AND RETRIEVAL SYSTEM

DOWNLOAD FILE

A. Windows Instructions	B. Macintosh Instructions
• Right-Click on the **DOWNLOAD FILE** link above • Select **Save Target As...** from the menu • In the Save dialog box, choose the folder (directory) where you wish to store the file and click the **Save** button • To use the file, open your application (Imaging for Windows or another graphics application that works with multi-page TIFF files) • Choose **Open** from the File menu • In the Open File dialog box, locate the folder (directory) where you saved the file • Select the file and click the **Open** button	• Click on the **DOWNLOAD FILE** link above and hold the mouse button down • Select **Save Target As...** from the menu • In the Save dialog box, choose the folder (directory) where you wish to store the file and click the **Save** button • To use the file, open your application (a graphics application that works with multi-page TIFF files) • Choose **Open** from the File menu • In the Open File dialog box, locate the folder (directory) where you saved the file • Select the file and click the **Open** button

Return to Document

Applied Research, Inc.

Huntsville, Alabama • Arlington, Virginia

"Focused On The Future . . . Committed To Excellence"

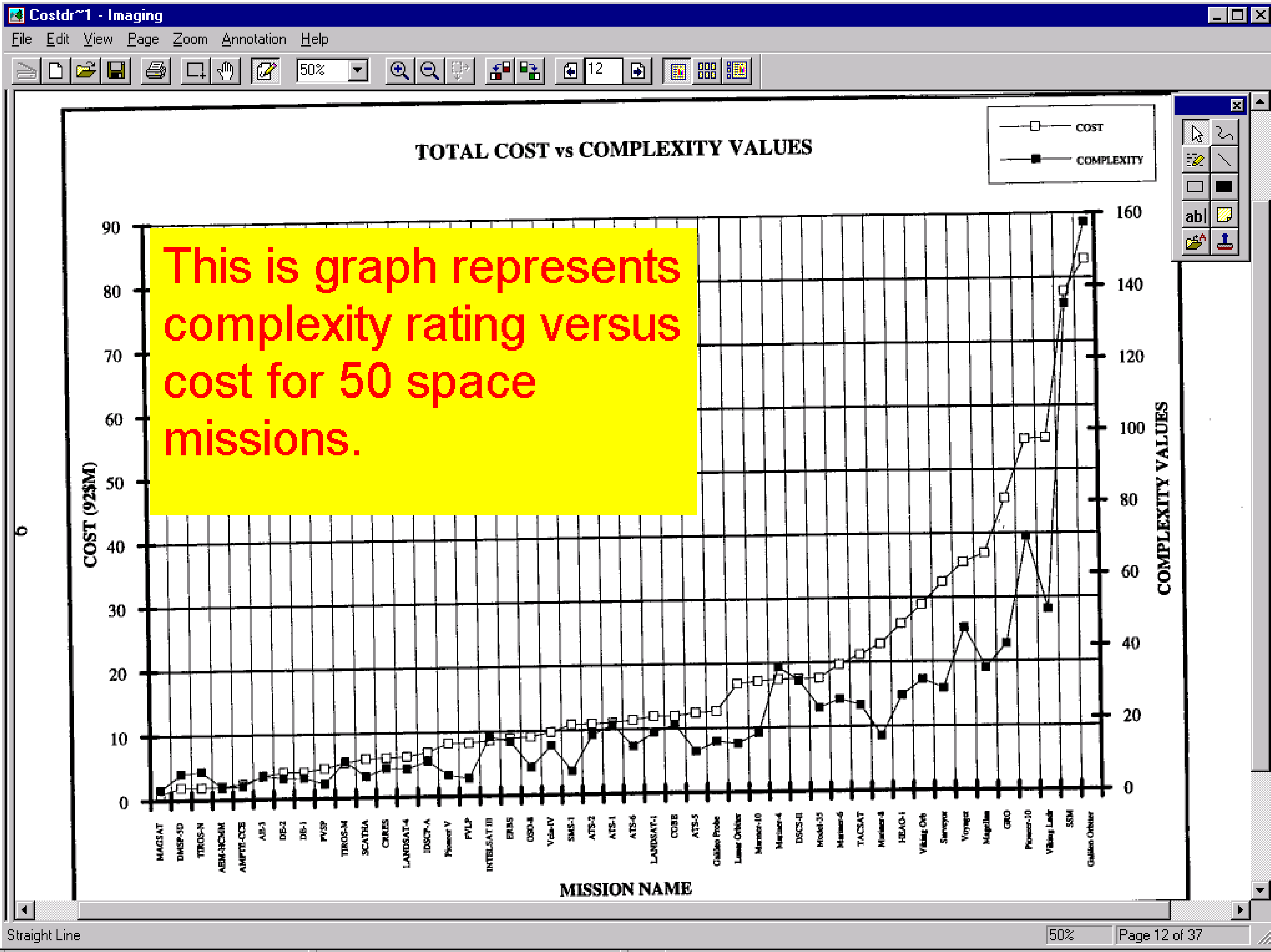
101-0194

Potential Cost Drivers for Unmanned Spacecraft Electrical Power Subsystems

July 2, 1993
ARI-93-R-062(Z)
Contract JPL 959313, CWO-5

Prepared for
California Institute of Technology
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91109

Prepared by
Applied Research, Inc.
6700 Odyssey Drive
Huntsville, Alabama 35806


Costdr~1 - Imaging
File Edit View Page Zoom Annotation Help
TOTAL COST vs COMPLEXITY VALUES
COST
COMPLEXITY
This is graph represents complexity rating versus cost for 50 space missions.
COST (92$M)
COMPLEXITY VALUES
MISSION NAME
0 10 20 30 40 50 60 70 80 90
0 20 40 60 80 100 120 140 160
MAGSAT
DMSP-5D
TIROS-N
AEM-HCMM
AMPTE-CCE
AE-3
DE-2
DE-1
TIROS-M
SCATHA
CRRES
LANDSAT-4
Pioneer V
INTELSAT III
ERBS
OSO-8
Vela-IV
SMS-1
ATS-2
ATS-1
ATS-6
LANDSAT-1
COBE
ATS-5
Galileo Probe
Lunar Orbiter
Mariner-10
Mariner-4
DSCS-II
Model-35
Mariner-6
TACSAT
Mariner-8
HEAO-1
Viking Orb
Surveyor
Voyager
Magellan
GRO
Pioneer-10
Viking Lndr
SSM
Galileo Orbiter
Straight Line
50%
Page 12 of 37